ORNL/TM-2000/67

COMMERCIAL PROGRESS AND IMPACTS OF INVENTIONS AND INNOVATIONS

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Energy Division

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ABSTRACT

This report presents the survey results from the 1997 inventions and innovations evaluation questionnaire. The evaluation impacts are based on responses from 136 out of 334 inventors sent the questionnaire.

In 1996, there were 67 inventions identified that currently have direct, licensed, or spinoff sales. In total, the number of inventions and innovations with current sales and past sales (now retired from the market) is 144. This represents a commercial success rate of over 27%. For these grant-receiving inventions, the following performance metrics are of interest:

- Total cumulative direct and licensed sales through 1996 were $700 million (1995$). In addition, cumulative spinoff sales and royalties were $90 million and $20 million (1995$) through 1996, respectively.

- Employment sustained by direct and licensed sales was 1189 full-time equivalents in 1996. Employment attributable to technologies with no sales was 90 full-time equivalents. The annual federal income taxes collected as a result of this employment was in excess of $6 million.

- Energy savings attributable to supported inventions and innovations were estimated at 78 trillion Btu in 1996 with a estimated value of nearly $190 million (1995$). The associated reduction in carbon emissions was over 1.5 million metric tons.

In terms of future commercialization progress and impacts, the 1997 survey revealed that 60% of the respondents are actively pursuing their invention, and nearly 50% of the inventions are in the prototype development, pre-production prototype testing, and pre-production development stages.

1. INTRODUCTION

1.1 Background

The Energy-Related Inventions Program (ERIP) was established in 1974 under the Federal Non-Nuclear Energy Research and Development Act to assist the development of non-nuclear energy-related inventions with outstanding potential for saving or producing energy. Since the inception of this program, over 32,000 inventions were submitted for technical evaluation, and more than 740 were considered for commercialization and financial assistance. Over 25% of the inventions that received grant support entered the marketplace. Cumulative sales and energy savings from these commercialized inventions now exceed more than $700 million and 0.8 quadrillion Btus, respectively.

DOE has systematically evaluated the economic, energy, and environmental impacts, as well as other factors, that have contributed to commercial success of energy-related inventions and innovations. In 1996, ORNL published the results of its sixth biannual evaluation, which was based on a comprehensive survey of inventors conducted in 1995. This report presents results of the seventh inventor survey. These results are based on a survey questionnaire completed by inventors during the summer and fall of 1997. The 1997 survey questionnaire is attached to the end of this report in Appendix A.

1.2 Inventor Surveying

The ORNL database currently has information on 672 inventors. In addition to the 672 inventors currently in the database, there are another 69 inventors (#s 673 to 741) who have not been surveyed. In 1997, questionnaires were mailed to 334 inventors. Two-hundred and seventy-two of these inventors were surveyed in previous years and were sent an abbreviated version of the questionnaire that contained their previous years responses. Sixty-two inventors were surveyed for the first time and were sent a full questionnaire. Of the 334 surveyed inventors, 78 inventors with current sales or with high potential for near-term sales were singled-out and given special attention and possible follow-up telephone interview. Three-hundred and thirty-eight inventors were not mailed questionnaires because they are no longer actively pursuing their invention, requested that they not be contacted, or could not be located.

Approximately 60% (194 out of 334) of the mailed questionnaires were returned by the inventors or current contacts. Of the 194 returned questionnaires, 149 were complete, 41 were undeliverable, 3 inventors requested that they be removed from future surveying, and 2 submitted a response by letter. Follow-up letters and faxes were sent to non-responding inventors. Telephone interviews were also

completed for those with sales or near term prospect of sales. For the 1997 survey, the total usable response nearly 50% and is nearly the same as the previous ORNL evaluation report.[1]

After completion of the 1997 survey, DOE's Inventions and Innovations Program requested that inventions be classified into separate categories in order to focus future technology tracking and impact evaluation efforts. Each of the 672 inventions was classified in seven categories based on information gathered from the 1997 survey and results of previous surveys. These categories are reported in Table 1.1.

Table 1.1. Categorization of inventions and innovations

Category	Description
Category I. Not funded.	These inventors did not receive a grant following a positive technical review.
Category II. Inactive.	Grant-receiving inventors who for a variety of reasons are no longer pursuing their invention.
Category III. Active grant.	Too early to tell if the technology will succeed.
Category IV. Technical success.	Grantees who have been technically successful and are now actively looking to commercialize their invention.
Category V. Retired.	Grantees who no longer report current sales or in actively in the market.
Category VI. Retired from market.	Retired from market with potential to return. Grantees who no longer report current sales or in actively in the market, but with the potential to return into the market and maintain contact.
Category VII. Commercial success.	Grantees who report current sales, licensed sales, or spinoff sales.

[1]Braid, R.B., M.A. Brown, C.R. Wilson, C.A. Franchuk, and C.G. Rizy, "The Energy-Related Inventions Program: Continuing Benefits to the Inventor Community", ORNL/CON-429, October 1996, Oak Ridge National Laboratory, Oak Ridge, TN.

Previous ORNL reports included non-funded technologies (Category I) in the evaluation metrics. Of the 672 inventors in the ORNL database 150 did not receive a grant. Of the 334 mailed questionnaires, 54 did not receive a grant. Although information was collected from the non-grantees, their responses were not included in sales and evaluation metrics contained in this report. Excluding the non-grantees lowers the total number of usable questionnaires to 136, for a response rate of 41%. In the past, these non-grantees were included because they received a preliminary and in-depth technical evaluation, a market assessment, and some commercialization assistance with the exception of a grant.

For the 672 inventions that have been tracked by ORNL, 205 are categorized as inactive. They are inactive for a variety of reasons – the invention was a technical or commercial failure, the inventor is no longer pursuing the invention after many years of attempt, the grantee has moved and cannot be located, the grantee has died, or the grantee simply refuses to communicate and cooperate. For the 1997 survey, inactive grantees are primarily those that were not mailed a questionnaire.

The results of ORNL surveying indicate that there are 142 Category III inventors out of a total of 672. These grantees are actively pursuing their invention, but it is too early in the invention development cycle to tell if they will be technically or commercially successful. Responses to the 1997 survey also show that 16 grantees report a technical success and are looking to begin commercial development of their invention. The grantees in this category were contacted and interviewed, if their questionnaire was incomplete or if they did not respond by mail. The 1997 survey and results of previous surveys show that 73 inventors are retired from the market (Categories V and VI). Finally, survey results show that there are 86 inventors that are reporting current year direct sales, licensed sales, or spinoff sales.

Figure 1.1 summarizes the current categorization of inventions. Excluding invention categories I, II, V, and VI, there are 158 inventions that are being pursued (about 24%) and 86 inventions with current sales.

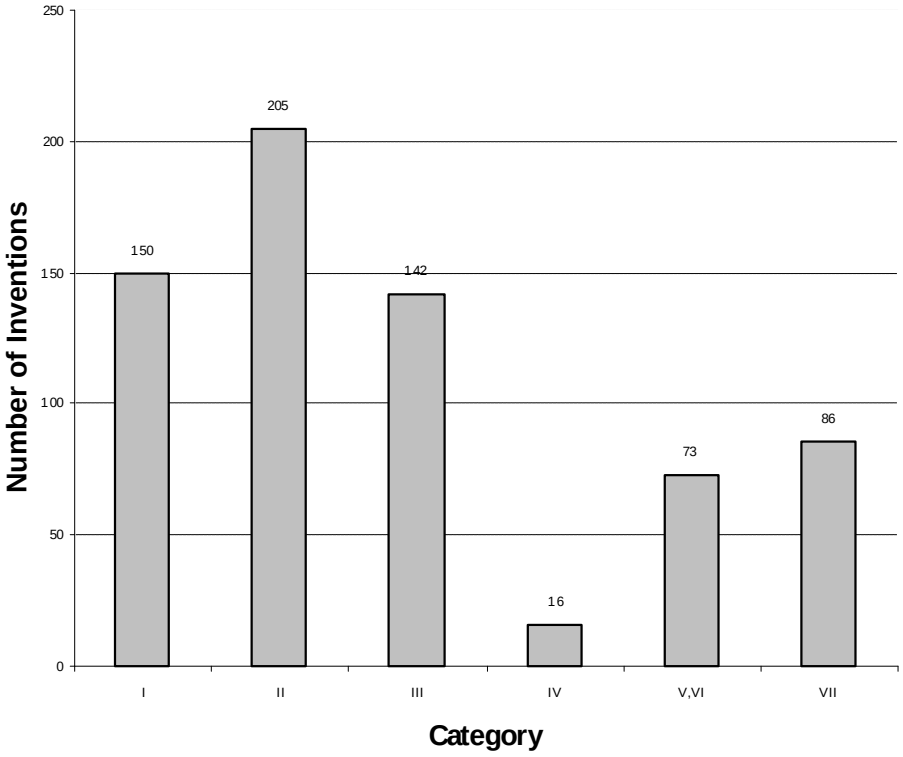

Figure 1.1. Number of inventions by category.

2. COMMERCIAL PROGRESS

2.1 Current Status of Inventions and Innovations

Figures 2.1 through 2.4 present the activity and development status of the surveyed inventions in 1996. One-hundred seventeen grant-receiving inventors responded to activity status question. The majority of these inventors (60%) noted that they are actively pursuing their invention. Another 17% are pursuing their invention at a low level of effort, and about 19% have suspended development activity either temporarily or permanently. These results are somewhat consistent with the 1994 survey that showed 70% of surveyed inventions as actively being pursued, 12% being pursued at a low level, and 15% as being suspended indefinitely or temporarily.

One hundred five inventors responded to the stage of development question. The largest proportion of inventions (34%) are in the "prototype development/testing/engineering design" development stage. This is followed by another 35 (33%) that are either in limited production and marketing or full production and marketing stages. Nearly 5% of the inventors stated that sales of their product are declining or that their product has been superseded in the marketplace. These stages of development results are different from the 1994 survey. Relative to the 1994 survey, there are more inventions in the prototype development stage (34% vs. 20%), less inventions in the limited and full production stages (33% vs. 51%), and more inventions in the superseded stage (5% vs. <1%).

2.2 Number of Commercially Successful Inventions and Innovations

By the end of 1996, 112 inventions are known to have achieved sales. Another 28 inventions are known to have had sales in 1994. For these 28 inventors whom did not complete a questionnaire, sales estimates were extrapolated based on trends established in earlier years. Thus, the total number of inventions that currently have or are known to have sales is 144. This represents over a 27% commercial success rate for DOE grant-receiving inventors (144 out of 522).

2.2.1 Market Entries and Exits

Figure 2.5 portrays the market entries and exits of inventions from 1990 through 1996. A market entry in a particular year is an invention that had sales that year, but not the previous year. A market exit occurs when an invention did not have sales in the year in question, but did have sales in the previous year. Inventions "in the market" had sales during the year in question, as well as during the previous year.

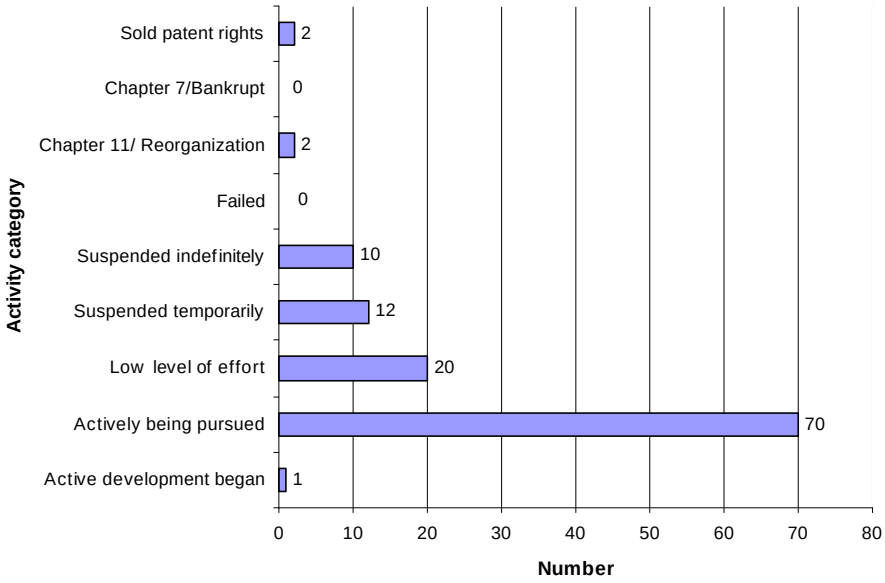

Figure 2.1. Activity status of responding inventions, 1996.

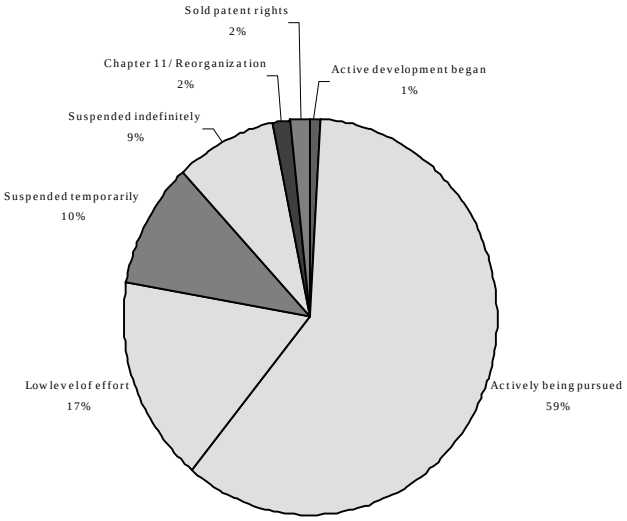

Figure 2.2. Proportion of projects by activity status, 1996.

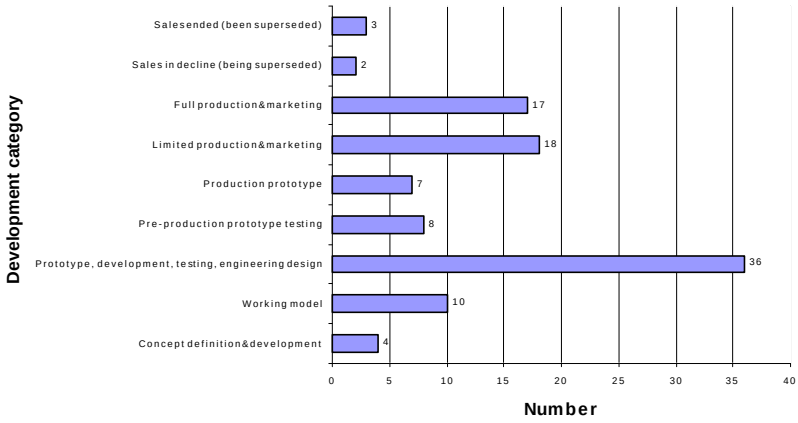

Figure 2.3. Development category of projects, 1996.

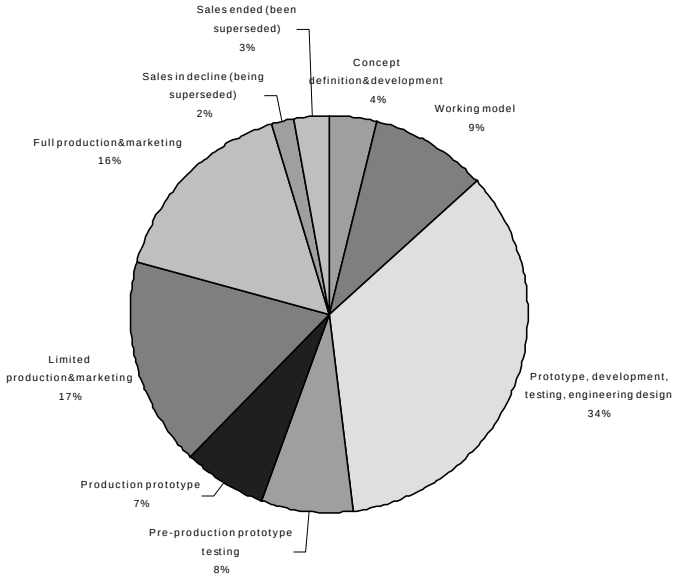

Figure 2.4. Proportion of projects by development category, 1996.

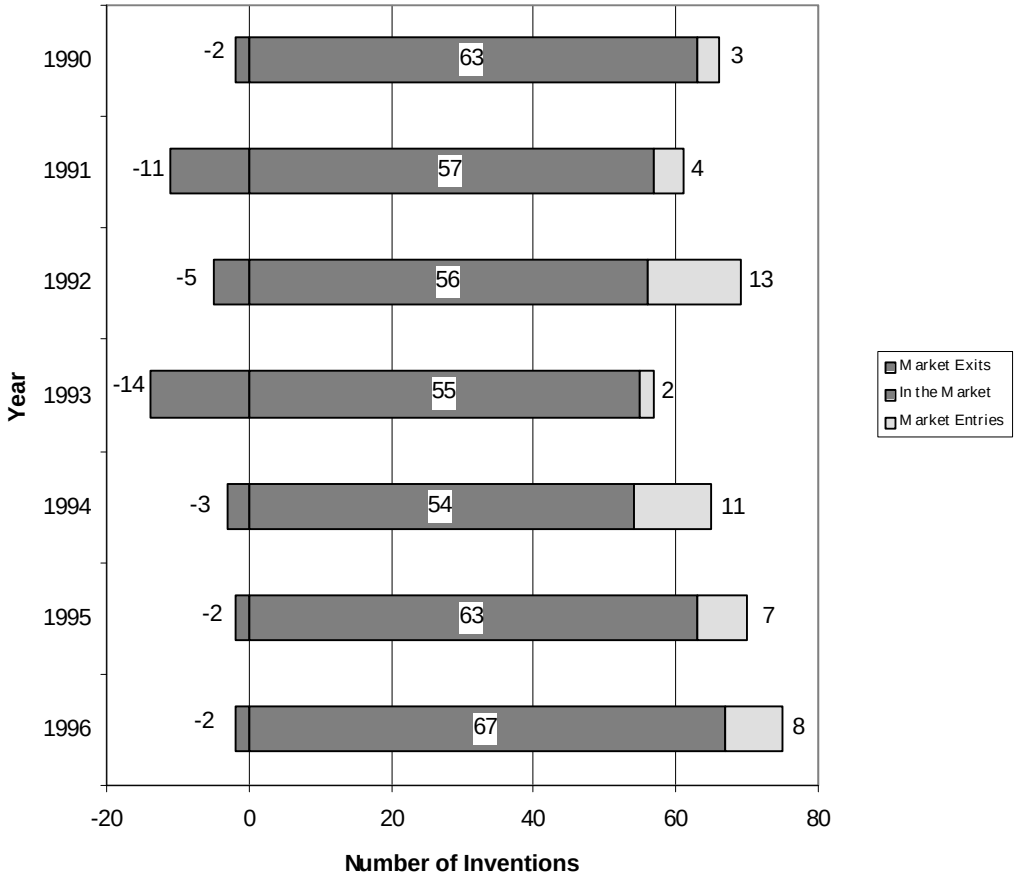

Figure 2.5. Inventions entering, in, and exiting the market.

Prior to 1990, 90 inventions entered the market. Of those, 64 exited before 1990 and only one was still in the market in 1996. The number of inventions and innovations in the market varies slightly from 1990 to 1996, going from 63 inventions in 1990 to 67 in 1996, with 54 being the low number in 1994. There were more inventions in the market in 1996 than in any other year. In 1991 and 1993, market exits (denoted by negative sign) outnumber market entries. Many of the market exits in 1991 and 1993 are due to missing sales data, rather than an absence of sales.

2.2.2 Market Entries by Mode of Commercialization

Three different modes of commercialization have been used by inventors to achieve sales:

- inventors have used their existing company (or their small business employer) as the business infrastructure for developing and marketing their technology (i.e., existing companies);
- inventors have created new business ventures to launch their technologies (i.e., new ventures); and
- inventors have licensed or sold their technologies as a means of bringing their technologies to market (i.e., licensing).

Figure 2.6 displays the number of inventions by commercialization mode. Between 1990 and 1996, 156 companies had sales: 64 inventors achieved sales through existing companies, 48 through new ventures, and 44 thorough licenses. Eight existing companies had both direct and licensed sales, while seven new ventures had both direct and licensed sales.

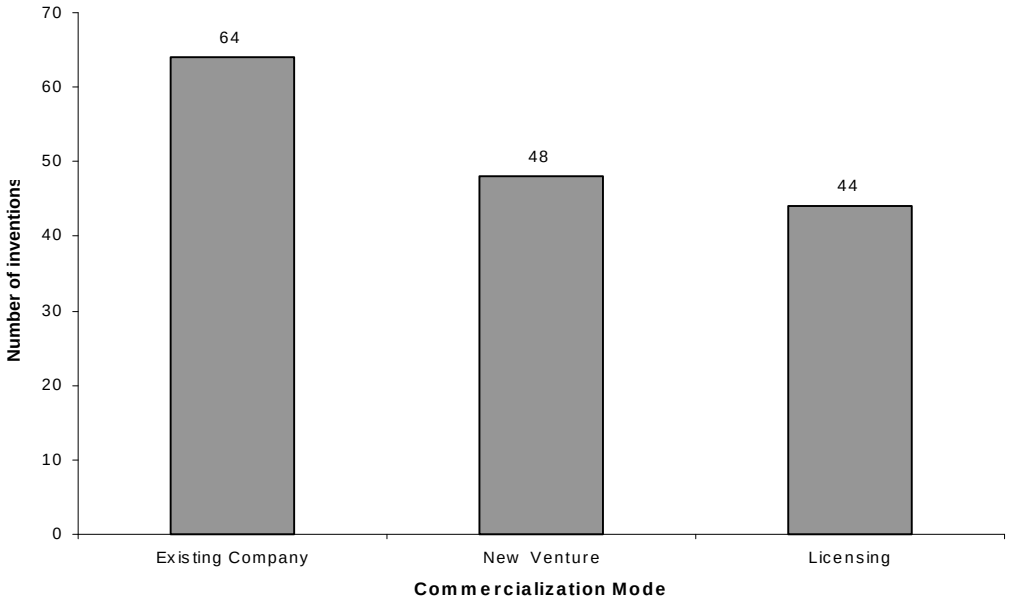

Figure 2.6. Proportion of inventions by commercialization mode.

2.3 Sales of Inventions and Innovations

It is estimated that total cumulative sales of inventions and innovations from 1980 through 1996 is $599 million in current dollars. This amounts to $709 million in 1995 dollars.

The total cumulative sales from 1980 through 1996 have varied significantly across inventions, from a low of $90 to a high of almost $110 million. Figure 2.7 shows a distribution of cumulative sales through 1996. Over 40% of grant-receiving inventions generated more than $1 million in total cumulative sales, and 27% of inventions generated less than $100,000 in sales.

A comparison of sales to costs (appropriations and grants) for 1990 through 1996 is shown in Figure 2.8. Although not explicitly shown in Figure 2.8, the inventions and innovations program has historically generated about a 20:1 return in terms of sales to grants, and a 8:1 return in terms of sales to total program expenditures.

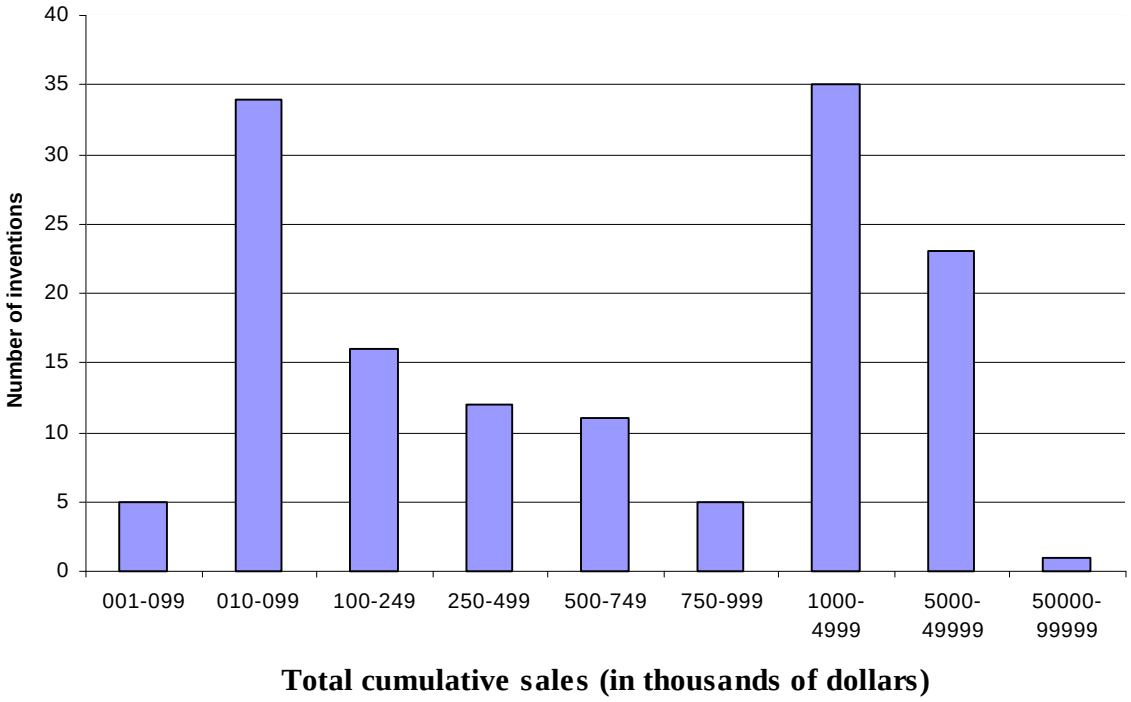

Figure 2.7. Distribution of cumulative sales through 1996.

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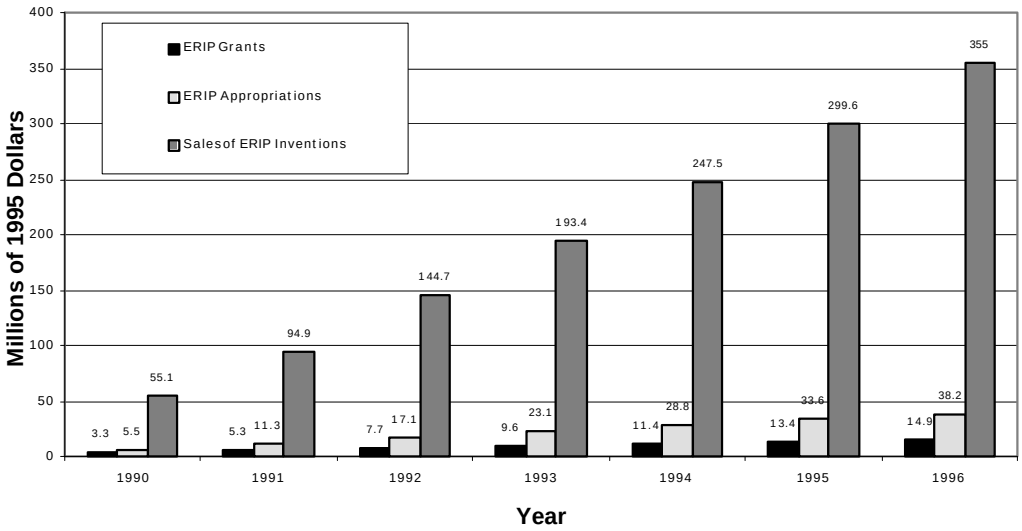

Figure 2.8. Cumulative grants, appropriations, and sales.

2.3.1 Direct and Licensed Sales

Total cumulative sales from 1980 through 1996 amount to over $709 million (1995 dollars). Of this amount, approximately $467 million are direct sales and $242 million are licensed sales. An historical depiction of licensed and direct sales, from 1990 through 1996 (in constant 1995 dollars), is shown in Figure 2.9. Direct sales reached the highest level in 1996, with over $40 million. On the other hand, licensed sales peaked in 1990 at $22 million. Total cumulative sales fluctuated during the period from $47 million in 1990 to $56 million in 1996. Figure 2.10 shows the relative percentages of direct and licensed sales over the 1990-1996 period.

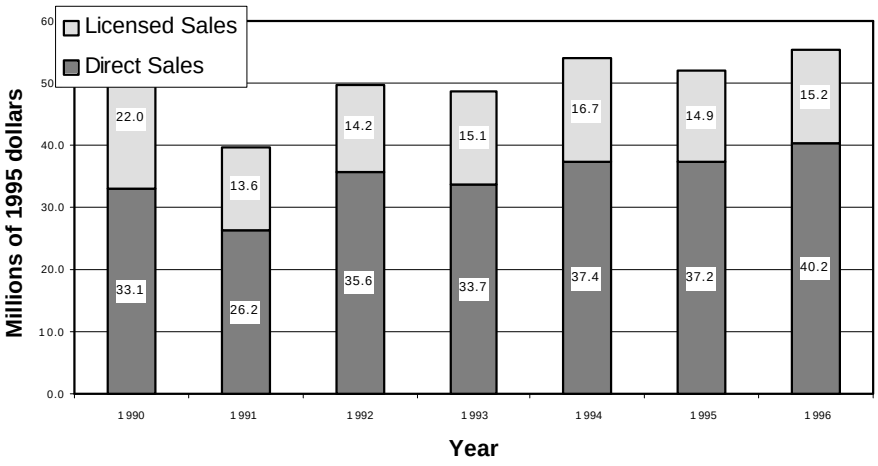

Figure 2.9. Licensed and direct sales.

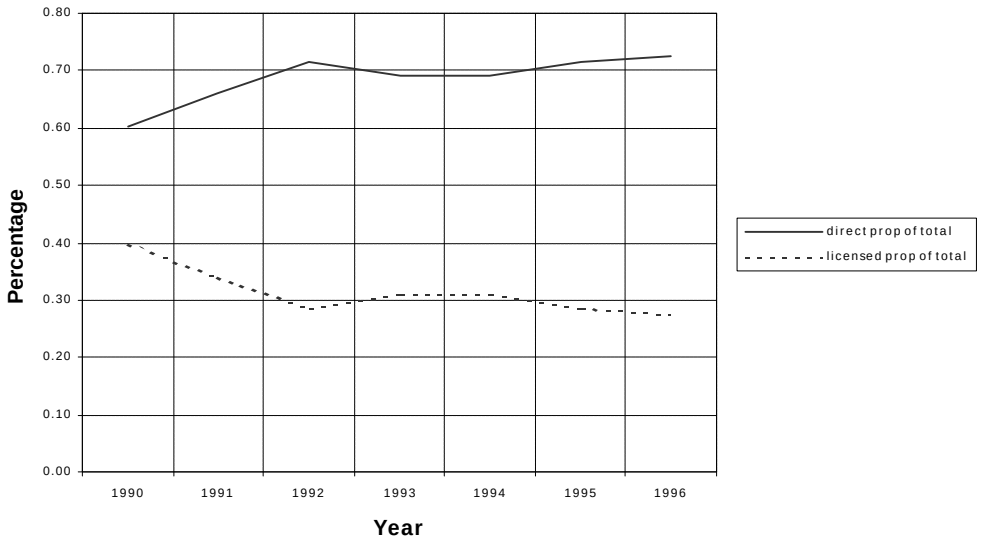

Figure 2.10. Direct and licensed proportion of total sales.

2.3.2 Foreign and Spinoff Sales

As of 1996, 59 inventors reported foreign sales, although nine of these did not provide sales figures. The total amount of foreign sales is $39.6 million, or approximately 12% of total cumulative sales. Cumulative spinoff sales through 1996 amount to $90.7 million in 1995 dollars.

2.3.3 Royalties

Royalty payments for 1980 through 1996 amount to approximately $20.5 million in 1995 dollars. Figure 2.11 shows the historical trend in royalties from 1990 through 1996 in constant 1995 dollars.

2.4 Industries of the Future

Each of the 144 inventions with both sales and a grant by IOF category was classified. Of the 144, 46 inventions were determined to correspond to a current and/or historic IOF category. In particular, six inventions had two applications and 40 inventions were classified in one IOF category. The results of this exercise are found in Figure 2.12. With the exception of the glass IOF, inventions are distributed rather evenly across two groups of IOFs. There are eleven applications in each of the steel, chemical, and agriculture categories, while petroleum refining has four applications, and aluminum and metal casting each have three.

In 1996, the total sales for the 46 IOF inventions amounted to 38% of cumulative sales for the 144 inventions in that year. There are 15 inventions with sales in 1996 of $1 million or more. The sales for these 15 inventions is 78% of the total sales of the whole sample of 144. Of the 15 inventions, five have IOF applications. Of these five inventions, two have application in petroleum refining, two in chemical, and one with applications in both petroleum refining and chemical.

A ranking of the difficulty (0 = not applicable to 7 = extremely difficult) of potential market obstacles was requested. The responses are shown in Figure 2.13. The most difficult obstacle was raising capital, followed by three obstacles related to market resistance and acceptance.

The majority of those inventors who contributed additional written comments related difficulties associated with gaining acceptance of a new or nontraditional method of doing something that has been done a particular way historically. This remark was applicable across IOF industries. The other most prevalent remark related to obtaining capital for further development and demonstration.

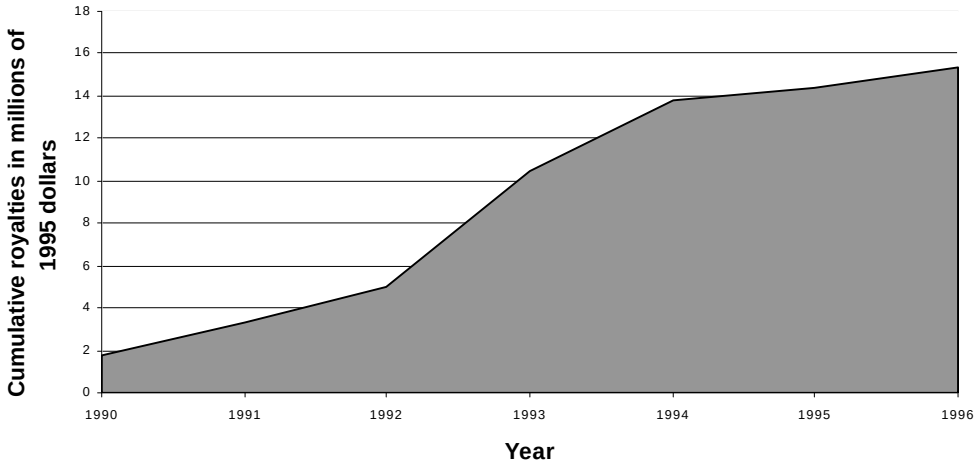

Figure 2.11 Cumulative royalties from inventions.

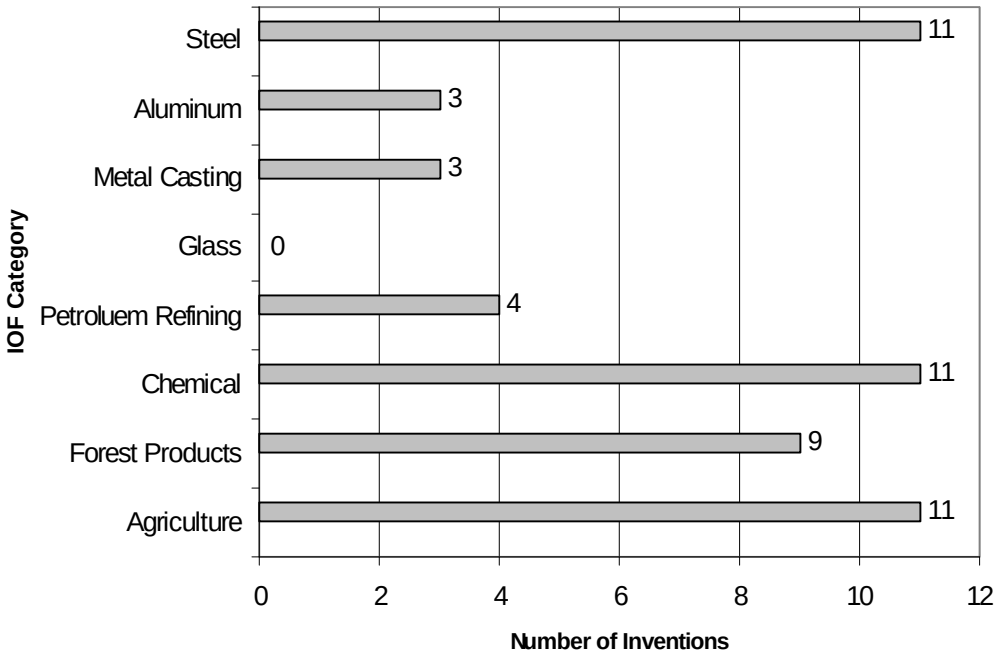

Figure 2.12. Number of inventions by IOF category.

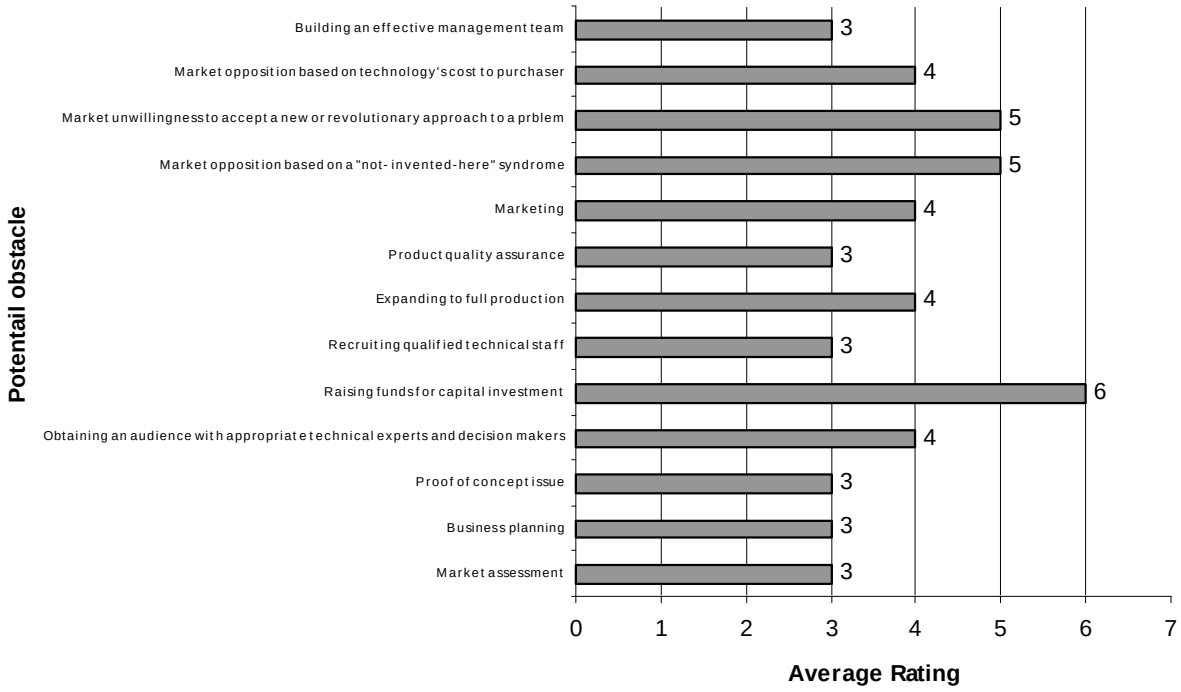

Figure 2.13 Average difficulty ratings of market penetration obstacles.

Finally, with regard to foreign market penetration, comments related to difficulties presented by patent protection, distance (geography), rules, permits, political constraints, and the inventor's own ignorance about exporting.

3. EMPLOYMENT AND TAX REVENUE IMPACTS

3.1 Employment

The 1997 questionnaire collected data on the number of direct, full-time equivalent (FTE) employees working on the development, production, and marketing of technologies between 1990 and 1996 (Figure 3.1). In 1995 and 1996, the number FTEs from those inventors responding to the questionnaire rose sharply to 1243 and 1279, respectively.

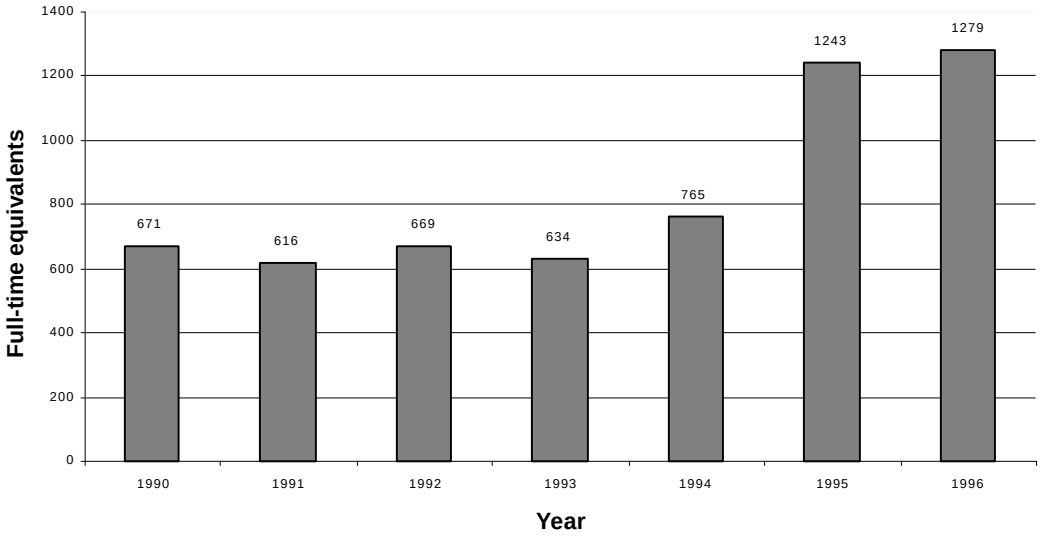

Figure 3.1. Direct full-time equivalents sustained by inventions, 1990-1996.

Employment is associated with technologies with direct and/or licensed sales, as well as with technologies with no sales. When sales are known, but employment figures are unavailable, employment estimates are generated from the ratios of sales to FTEs. Figure 3.2 shows a breakdown of total employment attributable to each of its three components. As can be seen, direct sales are responsible for the majority of employment.

3.2 Tax Revenues from Created Jobs

Tax revenues are estimated by finding the product of the number of employees working directly on inventions and innovations and the average federal income tax. This product provides an approximate estimate of the total federal taxes that can be attributed to the program. According to the 1996 Statistical Abstract, the average federal income tax per return was approximately $4600 in 1993. In 1996, grant-receiving inventions and innovations employed 1279 people. Assuming that each employee paid $4970 (1995$) in federal income taxes, total federal income taxes amounts to $6.36 million. This amount is 15.7% of 1996 appropriations to the inventions and innovations program.

Sponsored technologies also contribute revenues to the federal treasury through corporate income taxes and royalty payments, and to state and local treasuries through payment of state and local sales taxes and state income taxes. In addition, there are tax revenues contributed to federal, state, and local treasuries by those indirectly employed (e.g., suppliers).

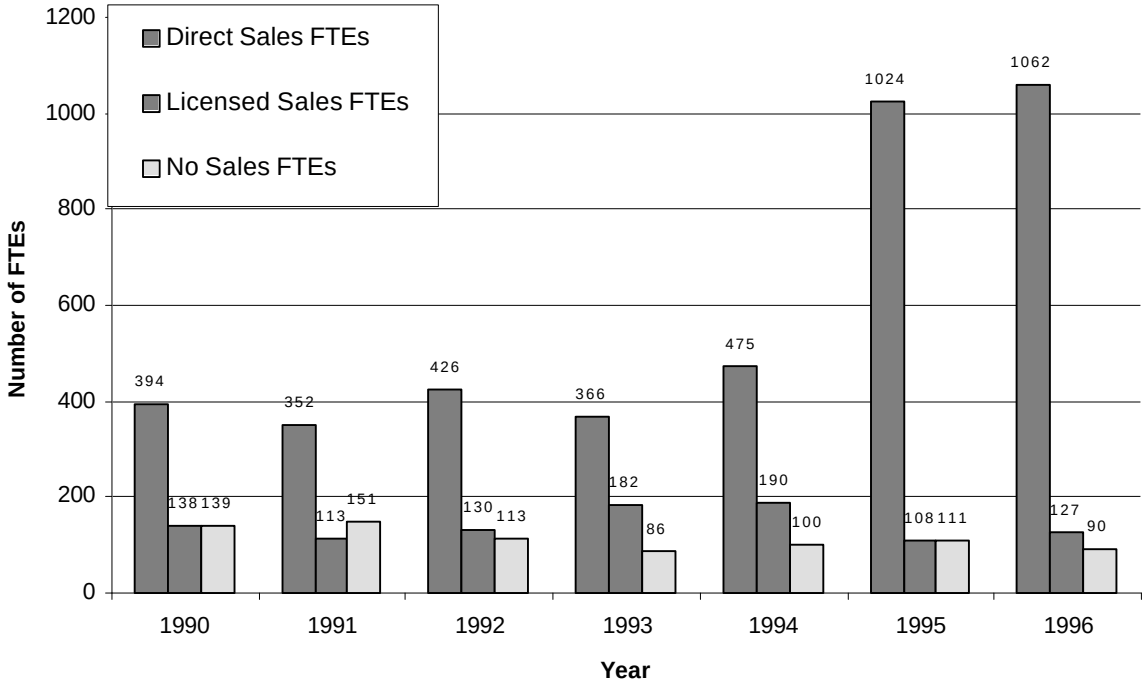

Figure 3.2. Components of total employment.

4. ENERGY SAVINGS AND ENVIRONMENTAL IMPACTS

Technologies supported by the inventions and innovations program offer a wide array of energy and various environmental benefits. Results of a recent survey of inventors with sales show that over 90% claim that their invention has energy efficiency improvement benefits (Figure 4.1). Pollution reduction benefits were cited by two-thirds of those inventors with sales. Non-renewable energy production and waste reduction were reported by 23% and 18% of inventors, respectively. Only 10% of inventors with sales reported that their technology offered renewable energy benefits. Finally, 75% of inventors reported that their technology offered other benefits such as product quality improvements (e.g., increased reliability and product life) and reduced manufacturing costs through lowered labor and/or material input requirements.

In this section, the results of an evaluation of technologies for energy savings and reduced emissions of carbon are shown. These results are based on an evaluation of 19 technologies. They represent approximately 30% of technologies that have had either direct sales, licensed sales, or spinoff sales. However, the 19 technologies represent a much larger fraction of total cumulative sales and current year sales. In 1996, sales for these 19 technologies accounted for 50% of total current year sales.

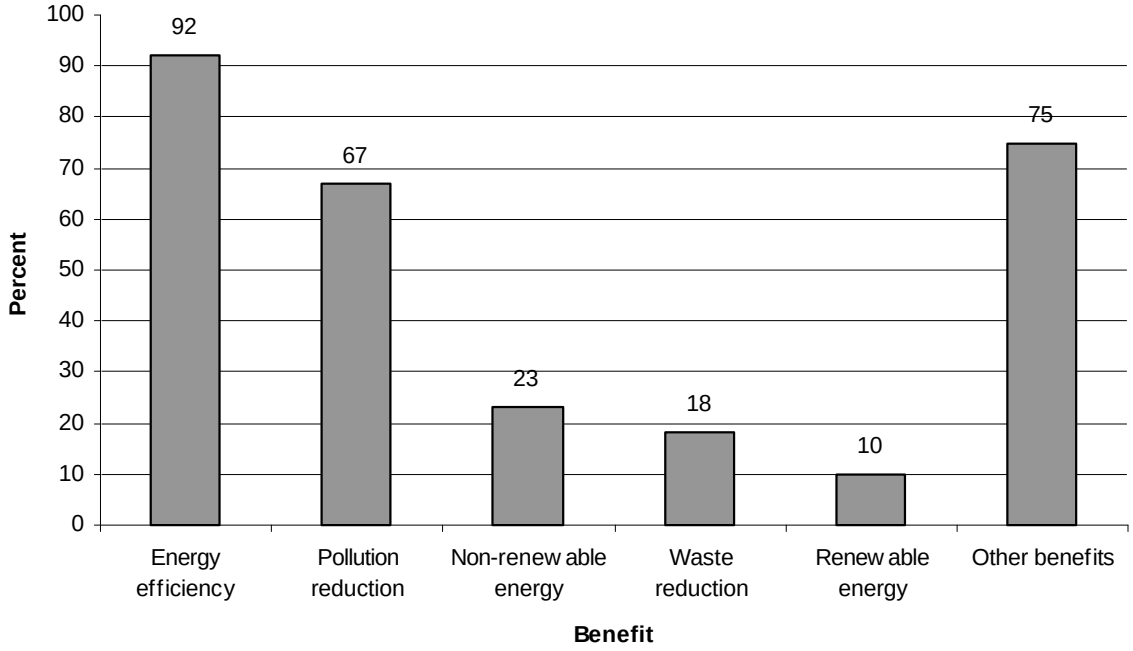

Figure 4.1. Technology benefits (sample of 19 technologies).

These 19 commercialized technologies were chosen for energy savings evaluations because they represented technologies where savings could be estimated based on the availability of documentation and resources. The available documentation included technical evaluation reports, ORNL questionnaires, secondary literature sources, as well as information directly from the inventor or technical contact. For many of the other inventions with sales, it is not possible to estimate energy savings credibly because the technology is used in process applications in which energy savings depend on the specific application, the technology provides primarily product quality improvements, or the technology deals with cost reduction and the energy or environmental benefits are of an indirect nature.

The inventions examined in this section for energy savings and environmental benefits include:

Number	Invention title/description
53	*High Efficiency Water Heater* — A direct contact, gas-fired hot water heater that can extract the latent heat of the water vapor formed during combustion.
88	*System-100* — A strategy (control system) for regulating centrifugal and reciprocating equipment used in natural gas compressor stations.
100	*SolaRoll* — A flexible rubber tubing solar collector for hot water and building heating systems. Collector is extrusion of ethylene-propylene-diamine rubber.
171	*A Method of Preserving Fruits and Vegetables without Refrigeration* — A method for preserving fruits and vegetables without refrigeration by using controlled atmosphere packages to keep oxygen levels low and the water vapor and carbon dioxide levels at desired optimums.
236	*Steam Turbine Packing Ring* — A self-adjusting steam turbine packing ring that provides large shaft clearance during turbine start-up and reduced shaft clearance at normal turbine operating speeds. This action avoids packing ring damage during start-up and results in higher operating efficiency. A private company is funding further development.
272	*V-Plus System* — A method to cool lubricating oil in a positive displacement rotary screw compressor. A variable speed pump injects liquid refrigerant into the compressor discharge line.
283	*Aluminum Roofing Chips* — A reflective coating for application to built-up roofing. Aluminum chips are spray-applied to surfaces with good adhesion. They may be site applied by blowing out on a surface with good adhesion or factory applied to make a roll goods with a reflective coating.

298 *Three Tenths Degree Kelvin Closed Cycle Refrigeration System* — Closed cycle refrigeration system to provide cooling to 0.3 Kelvin. Does not consume helium or other liquid cryogens.

322 *Electrical Resistance Cooking Apparatus with Automatic Circuit Control* — A method of using high frequency energy to cook meat for fast food vendors. The key feature is the lack of need for a vent. A new way of cooking hamburgers using the dielectric resistance characteristic of meat. The meat patty is placed between two parallel electrodes (flat plates). Heating takes place due to electric resistance. As the meat is cooked, resistance increases, thus decreasing the flow of current A sensor detects this gradual drop in current an de-energizes the circuit at preselected values in accordance with the level of cooking required. The estimated time for cooking a well-done hamburger with this method is less than 30 seconds.

371 *Wallace Energy Systems A/C Heat Pump Water Heater* — An electric heat pump consisting of three major components (outdoor unit or compressor section, indoor fan coil unit, and hot water storage tanks). System Function: Space heating; Space cooling with DX coil; Space cooling with water heating recovery; Water heating using heat pump system.

383 *Electro-Optic Inspection of Heat Exchangers* — A laser based system to inspect heat exchanger tubing for internal corrosion, erosion, scale buildup and deformation. An articulated probe is capable of negotiating and rapidly inspecting straight and bent tubing. The results are acquired, stored and displayed on a portable computer system with graphics capability.

412 *Meta-Lax Stress Relief for Almost any Size Metal Structure* — A method for using sub-resonant cyclic vibration excitement to relieve processing stresses in metal structures, including welding stresses during sub-resonant vibration.

473 *Energy Saving Head Pressure Control System for Air Cooled Condensers* — A pressure control system that increases the energy efficiency of refrigeration systems during cold weather. Use is limited to air-cooled refrigeration systems that have packaged condensing units or remote condensers with adjacent liquid receivers.

475 *Auxiliary Air Conditioning, Heating and Engine Warming System for Trucks* — An auxiliary power unit for trucks that contains a small diesel engine, electrical alternator, water pump, air-conditioner compressor, and heat exchangers and is intended to keep truck systems operating and the truck engine warm when the truck engine is not operating.

501 *High-Efficiency Dehumidifier/Air-Conditioner Using Heat Pumps* — A system of heat pipes that are placed in the air-ducts of an air-conditioning system to transfer heat between the return and supply ducts and thereby increase the dehumidification capability of the system. By passively pre-cooling the return air and reheat the supply air, the heat pipes allow the use of a smaller compressor and the suppression of the conventional reheat permitting energy savings up to 50%.

519 *Aerocylinder* — Airspring bellows manufactured by Firestone Industrial Products are combined into assemblies for use on machines (such as punch presses), in place of conventional air cylinders, to control motion and large masses. The air springs act as counter balancers and press cushioners and eliminate the alignment problems associated with conventional air cylinders.

536 *Delta T Dryer Controller* — A control system for industrial dryers that uses temperature drop information through the dryer to predict the moisture content of the plywood being dried. The proposed controller will result in less under-dried product that requires re-drying and less over-dried product that uses fuel. It also has application to drying other products such as carpet, pet food, pulp and paper, starch, feed, etc., and in clothes dryers.

540 *Restaurant Exhaust Ventilation Modulator* — A control system for the kitchen hood exhausts used in commercial applications. The purpose of the control system is to minimize energy losses in kitchen hood exhaust systems. It varies the amount of exhaust air through the kitchen hood in accordance with the cooking activity at any given time.

545 *System for Reducing Heat Losses from Indoor Swimming Pools By Use of Automatic Covers* — A plastic cover for use in an indoor swimming pool. The cover has an electro-mechanical mechanism for deploying and retracting the cover. Significant energy savings are expected from use of the cover to prevent water evaporation during times that the pool is not in use.

4.1 Energy Savings from Supported Technologies

As noted above, 19 technologies were evaluated for energy savings. The methods used to estimate savings varied among the technologies. A brief summary approach is provided below:

Number	Invention title/description

53 *High Efficiency Water Heater* — The estimated energy savings is a product of hours of usage per year and energy consumption per hour. The estimated energy use for a

conventional water heating system is calculated by applying the ratio of the differences in efficiency for the Therm efficient-100 and conventional systems (98% vs. 70%). The estimated energy savings is the difference between the energy use for conventional system and the Therm efficient-100 system.

88 *System-100* — Energy savings are calculated for two types of compressors — natural gas-powered pipeline compressors and steam-powered industrial compressors. Savings for natural gas compressors using the System-100 controls can exceed 11% depending on specific operating conditions. For process compressors powered by steam, energy savings have been measured as high as 10%. A conservative estimated savings of 5% was assumed for both compressor types.

100 *SolaRoll* — Savings are estimated using a model of swimming pool energy costs. Modeling results show annual savings of approximately 0.233 MBtu/ft^2 for pools using electric heat pumps and 0.089 MBtu/ft^2 for pools heated by natural gas. It was assumed that 70% of the square footage of SolaRoll is applied to natural gas heated pools and 30% to heat pump heated pools.

171 *A Method of Preserving Fruits and Vegetables without Refrigeration* — Energy savings are based on the elimination of the diesel fuel used to power small (27hp) refrigeration compressors. Savings are estimated at approximately 10% of diesel fuel used in transporting fresh fruits and vegetables.

236 *Steam Turbine Packing Ring* — the Brandon retractable steam turbine packing rings are used to reduce steam leakages in turbines. Savings are estimated as a function of turbine capacity (kW), consumption (Btu/kWh), capacity factor (hrs), and a savings and wear factor.

272 *V-Plus System* — Unit energy savings due to improved cooling of rotary screw compressors was estimated at approximately 440 MBtu per unit. Annual sales have averaged 38 units.

283 *Aluminum Roofing Chips* — Energy savings come from reduced air-conditioning loads and reduced bitumen material requirements in roof flood coats. Aluminum roofing chips can save approximately 20% of the energy required for air-conditioning due to roof loads (5%). Energy savings due to reduced material requirements are about 560 Btu/ft^2.

298 *Three Tenths Degree Kelvin Closed Cycle Refrigeration System* — Energy savings for this refrigeration system are estimated at approximately 150 MBtu per installation.

322 *Electrical Resistance Cooking Apparatus with Automatic Circuit Control* — Each unit can save 0.15 MBtu/day after correcting for the difference between the electric IB cooker and a conventional gas griddle. Savings are based on a scenario of 400 burgers per day over an 8-hour work shift with 360 operating days each year.

371 *Wallace Energy Systems A/C Heat Pump Water Heater* — Annual energy savings for this solar assisted heat pump water heater are estimated at 68,800 kWh of delivered electricity for each unit installed.

383 *Electro-Optic Inspection of Heat Exchangers* — Energy savings from using the laser-based system to inspect heat exchanger tubing are estimated at 810 MBtu per unit. These savings are in primary electricity production.

412 *Meta-Lax Stress Relief for Almost any Size Metal Structure* — Energy savings are estimated indirectly according to market share. There are 1200 Meta-Lax units in operation with about 90% of them doing stress-relief. If it is assumed that the potential market for Meta-Lax is 70,000 units, then energy savings are approximately 1.7 billion ft^3 of gas assuming total stress relief energy consumption of 200 billion ft^3 with 50% of this amount as potentially saved.

473 *Energy Saving Head Pressure Control System for Air Cooled Condensers* — Retrofitting the head pressure control systems for air-cooled condensers can save approximately 15,000 kWh of delivered electricity in each installation.

475 *Auxiliary Air Conditioning, Heating and Engine Warming System for Trucks* — The energy savings due to this heating unit that is designed to keep truck systems operating and the engine warm can save about 1585 gallons of diesel fuel each year. The equivalent of 219 MBtu annually. Installations have averaged about 80 units over the last 10 years.

501 *High-Efficiency Dehumidifier/Air-Conditioner Using Heat Pumps* — In residential and commercial applications not using reheat, the technology can save about 15% over a conventional system. In commercial applications requiring excess cooling to remove humidity and then reheating conditioned air by electricity can reduce energy consumption by about 55%.

519 *Aerocylinder* — Reducing compressed air leakages in metal stamping presses can reduce energy requirements by about 240 MWh of delivered electricity annually.

536 *Delta T Dryer Controller* — Energy savings can from three sources — increased material throughout with little or no increase in energy per unit time, reduced volume of material that must be re-dried, and reduced variability in output moisture content. The three sources of energy savings amount to 36%. However, it is not possible to realize all savings simultaneously. A conservative estimate of one-half the maximum (18%) energy savings was used.

540 *Restaurant Exhaust Ventilation Modulator* — The energy savings for the exhaust fan control system are based on a standard 8 x 6 foot hood. Reduced fan power and conditioning of make-up air is about 0.93 MBtu/hood. Through 1996 there were 67 units in operation.

545 *System for Reducing Heat Losses from Indoor Swimming Pools By Use of Automatic Covers* — Reducing water evaporation losses when indoor pools are not in use has the potential to save approximately 2445 MBtu per installation each year. Through 1995 there were 326 units in operation.

In calculating the energy savings and the value of these savings a number of common assumptions are made. Energy savings are attributed only to sales which occur after a grant has been received. Energy savings are counted for a full 12 years of sales, and each year of sales is assumed to remain in the market for 12 years (or less in the case of technologies whose normal useful life is less than 12 years). For example, a technology that entered the market in 1986 would be counted until year 1998 and sales in year 1998 would contribute to energy savings until year 2010. Year 2010 energy savings would be based only on year 1998 sales and would not include year 1997 or earlier sales.

Since the estimates of energy savings and reductions in carbon emissions are used in DOE/OIT data and information requests, including GPRA (Government Performance and Results Act of 1993) and other legal requirements, a set of consistent DOE/OIT guidelines were followed in calculating energy savings and carbon emissions. These assumptions include the conversion and energy content of primary fuels (oil, coal, and natural gas), the conversion efficiency between primary and delivered electricity, the electricity generation mix (80% coal, 15% natural gas, and 5% oil), and the carbon content of the primary fuels.

Table 4.1 summarizes the estimated energy savings and the value of these savings for the most recent year of commercial sales. These estimates represent the savings of all sales or units in service during 1996. However, these estimates do not include savings on sales made before 1984. In 1996, total primary energy savings for the 19 evaluated technologies amount to over 78 trillion Btu with a total value of nearly $190 million (1995$). The energy savings are split almost equally between natural gas and coal. A small percentage (3.2%) is oil. For most of the technologies total energy savings are less than 1 trillion Btus. The bulk of the energy savings come from just two inventions — System-100 and

the Brandon steam packing rings. These inventions account nearly 91% of the total energy savings in 1996.

4.2 Reduced Emissions of Carbon from Supported Technologies

Estimated reductions in carbon emissions are reported in Table 4.2. These estimates come directly from the product of the energy savings in Table 4.1 and a carbon coefficient for each primary fuel. These coefficients are 25.7, 19.7, and 14.7 metric tons per billion Btus for coal, oil, and natural gas, respectively. Total reductions in emissions of carbon from supported technologies exceed 1.5 million metric tons.

Table 4.1 Summary of primary energy savings and value of savings -- 1996

ERIP Invention #	Primary energy savings (billion Btus)				Value of savings (1995$ Millions)
	Coal	Oil	Gas	Total	
53	--	--	2954	2954	12.4
88	--	--	25792	25792	84.7
100	256	16	796	1069	7.0
171	--	1.4	--	1.4	0.01
236	36598	2287	6862	45747	68.1
272	388	24	73	485	2.1
283	8	0.5	2	10.5	0.08
298	21	1.3	3.9	26.2	0.2
322	--	--	226	226	1.2
371	21	1.3	3.9	26.2	0.19
383	198	12	37	247	0.39
412	--	--	1152	1152	3.8
473	17	1	3	21	0.15
475	--	133	--	133	1.1
501	255	16	48	319	2.5
519	103	7	19	129	0.56
536	12	0.7	133	145.7	0.62
540	3	0.2	0.6	3.8	0.03
545	19	1	49	69	0.43
Total	37899	2503	38154	78557	186

Table 4.2. Summary of reductions in carbon emissions -- 1996

ERIP Invention #	Reduction in carbon emissions (metric tons)			
	Coal	Oil	Gas	Total
53	--	--	43419	43419
88	--	--	379148	379148
100	6592	316	11704	18612
171	--	28	--	28
236	940561	45061	100872	1086494
272	9969	478	1069	11516
283	212	10	36	258
298	531	26	57	614
322	--	--	3322	3322
371	540	26	57	623
383	5089	236	544	5869
412	--	--	16934	16934
473	429	21	46	496
475	--	2624	--	2624
501	6554	315	706	7575
519	2643	127	283	3053
536	298	14	1952	2264
540	76	4	8	88
545	481	23	714	1218
Total	973975	49309	560871	1584155

5. SUMMARY EVALUATION FINDINGS

Preliminary findings indicate that there were 67 inventions with direct, licensed, or spinoff sales in 1996. By the end of 1996, 144 inventions are know to have had sales. This would represent a commercialization success of over 27%. For these grant-receiving inventions, total cumulative direct and licensed sales through 1996 were over $700 million (1995$) excluding spinoff sales and royalties. Cumulative spinoff sales and royalties were $90 million and $20 million (1995$), respectively. The employment attributable to this commercial success was 1062 full-time equivalents in 1996 from direct sales alone. The level of federal income taxes collected as a result of this employment was over $6 million annually. In 1996, energy savings were nearly 80 trillion Btu with an estimated value of nearly $190 million (1995$). The associated reduction in carbon emissions was over 1.5 million metric tons in 1996. The future prospects for inventions and innovations are very promising as 60% of the respondents stated that they were actively pursuing their invention.

APPENDIX A — 1997 Questionnaire

Primary Contact: Contact name

Project Number: xxx ERIP Grant: $xx,xxx Award Date: xx/xx/xx

TECHNOLOGY DESCRIPTION

The following title and description are based on the status of the technology when ERIP support was initially requested. Please revise them if they are no longer correct.

TITLE
ORIGINAL DESCRIPTION
REVISED DESCRIPTION

CONTACT INFORMATION

	CONTACT	INVENTOR
Name		
Company		
Address		
City		
State & Zip Code		
Home Phone		
Business Phone		
Fax Number		
e-mail		
Internet Address (Home Page)		

CONTACT'S ASSOCIATION WITH THIS PROJECT

We would like to know how you are related to this ERIP technology. Please check one or more boxes below. If your circumstance does not fit any of the listed categories, please describe it in the space provided.

Inventor G
Applicant G
Licensee G
Owner of technology G
Designated contact G

Developer of technology G
Other (Describe below) G

INVENTOR'S BACKGROUND AT TIME OF CONCEPTUALIZATION

We are interested in the inventor's background at the time when the ERIP invention was conceptualized. This information will help us to better understand the commercialization process of the invention.

Inventor's Name								
Company in which inventor Worked								
Number of employees in company	1-15		16-49		50-99		100-499	
	500-999		1,000-9,999		10,000+			

CONTACT'S EMPLOYMENT HISTORY

CONTACT'S MOST RECENT EMPLOYMENT								
Company								
Your Position or Job Role								
Number of employees in company	1-15		16-49		50-99		100-499	
	500-999		1,000-9,999		10,000+			
Years of employment	First Year			Last year				

CONTACT'S PREVIOUS EMPLOYMENT								
Company								
Your Position or Job Role								
Number of employees in company	1-15		16-49		50-99		100-499	
	500-999		1,000-9,999		10,000+			
Years of employment	First Year			Last year				

CONTACT'S EXPERIENCE WITH STARTUP COMPANIES

How many startup companies were developed to commercialize the ERIP technology?_____

	Startup #1	Startup #2
Company Name		
Location (City/State)		
Comments		

PATENTING ACTIVITY

How many U.S. and foreign patents have been issued to protect this technology? U.S.:_____ Foreign:_____

DEVELOPMENT AND ACTIVITY STATUS

This information helps us track the chronological development and activity status of the ERIP technology. Please use the following development and activity categories to update the table below.

DEVELOPMENT CATEGORIES

1 = Concept definition and development
2 = Working model
3 = Prototype development/testing/engineering design
4 = Pre-production prototype testing
5 = Production Prototype
6 = Limited production and marketing
7 = Full production and marketing
8 = Sales in decline (being superseded)
9 = Sales ended (been superseded)

ACTIVITY CATEGORIES

0 = Active development began
1 = Actively being pursued
2 = Low level of effort
3 = Suspended temporarily
4 = Suspended indefinitely
5 = Failed
6 = Chapter 11/Reorganization
7 = Chapter 7/Bankrupt
8 = Sold Patent Rights

Year technology originally conceptualized:_____

YEAR	DEVELOPMENT STATUS	ACTIVITY STATUS	COMMENTS
1990			
1991			
1992			
1993			
1994			
1995			
1996			

ENERGY, ENVIRONMENTAL, AND OTHER BENEFITS

We are interested in knowing about the features of your ERIP technology that you believe represent energy and/or environmental benefits to users or to the public. Please check all the boxes below that are applicable to your technology and provide a brief description for all those you check.

ENERGY BENEFITS

G Renewable energy production (solar, wind, etc.)

G Non-renewable energy production

G Energy efficiency improvement

ENVIRONMENTAL BENEFITS

G Pollution reduction

___ to air
___ to water
___ to soil

G Waste reduction

___ by using less material
___ by recycling

OTHER BENEFITS

G Other

___quality or performance improvements
___ reduction of manufacturing costs

SALES DATA

Information on sales of your ERIP technology is essential to our assessment of the assistance provided by ERIP. Please indicate cumulative sales figures for those years prior to 1990. For 1990-1996, please list an annual sales figure.

YEAR OF FIRST SALES OF ERIP TECHNOLOGY	

YEAR	SALES OF ERIP TECHNOLOGY		
	Total number of units sold by you, licensee or others	Sales by you to end users or distributors ($)	Sales by licensee or other organization ($)
Pre 1990			
1990			
1991			
1992			
1993			
1994			
1995			
1996			
Comments:			

If sales of your ERIP technology were by your company, please indicate whether sales were made by an existing company or a new venture. Existing Company G New Venture G

FOREIGN SALES OF ERIP TECHNOLOGY

The development of foreign markets for U.S. technology is of great interest to the Energy-Related Inventions Program. Please provide your foreign sales information in the table below.

Has your ERIP technology been sold outside of the U.S.?	G **YES** G **NO**
If yes, please estimate your total foreign sales to date. (These sales should also be included in the above table.)	**$**

LICENSING REVENUE

Information about licensing revenue helps us to examine the relative success of different approaches to commercialization. If your ERIP technology has not been licensed and its patent has not been sold, skip to the next page.

Royalties: These are total annual royalties received or paid out based on actual sales of your ERIP technology.

Royalty rate: This is the average royalty percentage per dollar sale. If multiple royalty rates are in operation, please give us a weighted rate.

Other licensing payments: This includes up-front payments, bonuses, or other licensing revenues not tied to actual sales.

LICENSE AND PURCHASE AGREEMENTS

YEAR	COMPANY	CITY & STATE

LICENSING REVENUE

If you have had licensing revenue prior to 1990, please indicate a cumulative figure for those years. For 1990-1996, please list an annual licensing revenue figure.

YEAR	ROYALTIES ($)	ROYALTY RATE (XX.X%)	OTHER LICENSING PAYMENTS ($)
Pre 1990			
1990			
1991			
1992			
1993			
1994			
1995			
1996			
Comments:			

EMPLOYMENT

Information about employment generated by your ERIP Technology helps us examine the degree to which the ERIP program has been successful in generating jobs.

Direct ERIP Employment: Please list only the number of employees of your company, or the company to which you licensed your ERIP technology, that can be directly attributed to the technology sponsored by the ERIP program.

Please use annual Full-Time Equivalents (FTE) (2 Half Time = 1 FTE)

EMPLOYMENT ASSOCIATED WITH THE ERIP TECHNOLOGY

YEAR	DIRECT EMPLOYMENT (Number of FTE)
1990	
1991	
1992	
1993	
1994	
1995	
1996	

Comments:

SOURCES OF FUNDING FOR ERIP TECHNOLOGY

Please use the following funding types when describing your sources of funding below.

TYPE OF FUNDING	EXAMPLES
Personal	inventor's own savings, friends and relatives, funds from the development team, and private stock offerings
Nonfinancial	sweat equity and in-kind contributions of customers or suppliers
Corporate	revenue generated through sales or royalties of the ERIP technology, internal funds from other sources of revenue, and loans from customers or suppliers
Commercial	venture capital firms, R&D limited partnerships, and other outside investors
Public Stock Offerings	public stock offerings
Lending Institutions	long-term loans to cover development costs, real estate purchases, etc., and short-term loans to cover inventory, etc.
State and Local Agencies	grants, R&D contracts, and loans from state and local agencies
Federal Agencies	grants, R&D contracts, and loans from federal agencies

If you need additional space, please use the back of this page.

YEAR	AMOUNT ($)	DESCRIPTION OF FUNDING (Please use the funding types above when describing your funding.)
Comments:		

SPINOFF TECHNOLOGIES

There are several ways in which spinoff technologies can arise.

1. Development of an initial technology results in new product characteristics that adapt the product for new markets.

2. Efforts to solve a problem with an initial technology fail, so a different approach is used to resolve the same problem and a new technology results.

3. A new application is found for a component of an initial product.

If any of the criteria above apply to your ERIP technology, please describe below your spinoff technologies that have been developed as a result of your ERIP project.

If you have more than two spinoff technologies, please use the back of this page.

DESCRIPTION OF SPINOFF TECHNOLOGY #1							
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Sales							
Licensing Royalties							

DESCRIPTION OF SPINOFF TECHNOLOGY #2							
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Sales							
Licensing Royalties							

INDUSTRIES OF THE FUTURE

The U.S. Department of Energy's (DOE) "Industries of the Future" Program focuses on improved energy savings technologies in the steel, aluminum, metal casting, glass, petroleum refining, chemical, and forest products industries. These seven industries consume 81% of the total energy used by the manufacturing sector, and they generate over 80% of the country's manufacturing wastes and air emissions. DOE would like to identify any lessons learned from your experience that might help the Industries of the Future Program. If your technology does not apply to any of the seven industries, please skip to page 13.

Please check each of the industries below in which there is current or potential application of your technology.

	Current	Potential		Current	Potential
Steel	G	G	Petroleum Refining	G	G
Aluminum	G	G	Chemical	G	G
Metal Casting	G	G	Forest Products	G	G
Glass	G	G			

Please answer the remaining questions with respect to the one "Industry of the Future" to which your technology is most applicable and where you have the most experience: _____ .

Please indicate the degree of difficulty the following possible barriers posed in entering and penetrating this industry.

	Not Applicable	Not at all Difficult			Somewhat Difficult			Extremely Difficult
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Market assessment	G	G	G	G	G	G	G	G
Business planning	G	G	G	G	G	G	G	G
Proof of concept issue	G	G	G	G	G	G	G	G
Obtaining an audience with appropriate technical experts and decision makers	G	G	G	G	G	G	G	G
Raising funds for capital investment	G	G	G	G	G	G	G	G
Recruiting qualified technical staff	G	G	G	G	G	G	G	G
Expanding to full production	G	G	G	G	G	G	G	G
Product quality assurance	G	G	G	G	G	G	G	G

Marketing	G	G	G	G	G	G	G	G
Market opposition based on a "not-invented-here" syndrome	G	G	G	G	G	G	G	G
Extremely	Not Applicable	Not at all Difficult			Somewhat Difficult			Difficult
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Market unwillingness to accept a new or revolutionary approach to a problem	G	G	G	G	G	G	G	G
Market opposition based on technology's cost to the purchaser	G	G	G	G	G	G	G	G
Building an effective management system	G	G	G	G	G	G	G	G
Others (please explain below)	G	G	G	G	G	G	G	G

If you have tried to enter a foreign market in this same "Industry of the Future," what have been your experiences?

ADDITIONAL COMMENTS

INTERNAL DISTRIBUTION

1. M. A. Brown
2. G. E. Courville
3. T. R. Curlee
4. C. A. Franchuk
5. R. G. Gilliland
6. D. F. Jamison
7. R. M. Lee
8. C. I. Moser
9-28. R. D. Perlack
29. D. E. Reichle
30. C. G. Rizy
31. R. B. Shelton
32. Central Research Library
33. Document Research Section
34. Laboratory Records

EXTERNAL DISTRIBUTION

35. Dr. Lilia A. Abron, President PEER Consultants, P. C., 1460 Gulf Blvd. Apt. 1103, Clearwater, Florida 33767.
36. Dr. Susan L. Cutter, Director, Hazards Research Lab., Department of Geography, University of South Carolina, Columbia, South Carolina 29208.
37.-136. Dr. Sandy Glatt, Inventions and Innovations, Office of Technology Access, Office of Industrial Technologies, Room 5F-065, EE-20, 1000 Independence Ave., SW, Washington, D.C. 20585-0121.
137. Dr. Stephen G. Hildebrand, Director, Environmental Sciences Division, Oak Ridge National Laboratory, Post Office Box 2008, Oak Ridge, Tennessee 37831-6037.
138. Mr. P. Richard Rittelmann, FAIA, Executive Vice President, Burt Hill Kosar Rittelmann Associates, 400 Morgan Center, Butler, Pennsylvania 16001-5977.
139. Dr. Susan F. Tierney, The Economic Resource Group, Inc., One Mifflin Place, Cambridge, Massachusetts 02138.
140. Dr. C. Michael Walton, Ernest H. Cockrell Centennial Chair in Engineering, Department of Civil Engineering, University of Texas as Austin, Austin, Texas 78712-1076.
141-42. OSTI, U.S. Department of Energy, Post Office Box 62, Oak Ridge, Tennessee 37831.
143. Office of Assistant Manager for Energy Research and Development, DOE/ORO, Post Office Box 2001, Oak Ridge, Tennessee 37831-8600.